Last-Mile Delivery Innovations
COVID-19 Challenges and Opportunities

FMRI Webinar
July 9, 2020

Prof. Miguel Figliozzi
General Context

Before COVID-19

- Other concerns…
- E-commerce double digit annual growth
- Robust package delivery industry growth
AMAZON SHIPPING COSTS & PRIME MEMBERSHIP

Billions, USD

Prime members, Millions


Dec-13 25

Jun-16 63

Jun-17 85

Jun-18 90

Dec-19 112

$5.1

$6.6

$8.7

$11.5

$16.2

$21.7

$27.7

$37.9
US MAJOR COURIERS: PACKAGE VOLUMES

<table>
<thead>
<tr>
<th>Year</th>
<th>USPS</th>
<th>UPS Deferred</th>
<th>UPS Next Day Air</th>
<th>UPS Ground</th>
<th>FedEx Express</th>
<th>FedEx Ground</th>
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<td>1.0</td>
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<td>3.4</td>
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<tr>
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<td>1.1</td>
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<td>3.8</td>
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</table>
General Context

During COVID-19

- E-commerce rapid increase
- Dramatic changes in demand patterns
- Supply chain realignments
E-Commerce trends

● Online sales will increase 18% in 2020 and brick and mortar down 14% (eMarketer's forecast)

● April/May online sales up 7% over 2019 holiday peak, 50+% over April/May 2019 (Adobe Analytics)
E-Commerce trends

- Walmart’s ecommerce sales increased by 74% in the first quarter of 2020

- Amazon posted $36.6 billion in sales in the first quarter of 2020, compared to $29.5 billion in the first quarter of 2019 (24% increase in online sales)
Food/Grocery Delivery

- Instacart order volume saw a 500% growth in April 2020 over April 2019
- Instacart: 150,000 shoppers Pre-COVID and 500,000+ shoppers in April
- 300% growth overall online, food and beverage fastest-growing category in ecommerce
Parcel Delivery - Hazard Pay

- Amazon instituted a base pay increase from $15 to $17 per hour for warehouse associates from April to June

- Labor unrest
  - Instacart Walkout
  - Amazon warehouse walkouts
Last mile and COVID-19

- Package/parcel deliveries
- Service deliveries
- Health risks and Labor issues
- Capacity challenges
- USPS
Autonomous (ground) Delivery Robots (ADRs)

- Deliver items to customers
- NO delivery person
- Travel on sidewalks/roads

SADRsvs RADR s

Tradeoffs: payload, speed, and range

Figure Sources: https://media.daimler.com/marsMediaSite/ko/en/15274799; www.nuro.ai
Starship’s Prototype Mothership

Diesel Mercedes-Bens Sprinter Cargo Van, carries up to 8 SADR

Human driven
Asia: coronavirus lockdown sparks expansion of drones and robot deliveries

ZhenRobotics's RoboPony and JD servicing retailers, hospitals, malls and apartment complexes
Temporary Hospitals in California: ferrying food, supplies, and medical equipment

NURO delivery robots

Mayo Clinic, Jacksonville, Fla.: transporting viral tests and supplies

NAVYA minibus

Fast changing landscape…

- Amazon
- Postmates
- FedEx
  - range 8 miles
  - tare 200 lbs,
  - payload 100 lbs, and
  - speed 10 mph

Typical SADR Regulations

- Weight limit up to 80 lbs (36kg)
- Speed limit of 10 mph (16kph)
- Follows pedestrian laws
- Insurance policy
- Headlights
- Brakes
Typical RADR Regulations

- Insurance policy (in the millions of USD)
- Operator must have driver’s license
- Manual override feature
- Applies to automation levels 4 & 5
Drone Types

- Multicopter vs Fixed-wing
- ICE engine vs Electric

Tradeoffs: cost, performance, flexibility, feasibility for urban applications.
Testbed Exceptions FAA regulations

“With the help of Flytrex and EASE Drones, we are deploying UAVs to limit unnecessary exposure to the coronavirus. We hope other communities will follow."

Grand Forks, ND, Mayor Michael R. Brown
<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Tare (kg)</th>
<th>Max. Speed (kph)</th>
<th>Payload (kg)</th>
<th>Range (km)</th>
<th>Approx. Energy consumption (wh/km)</th>
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<tr>
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<tr>
<td>Nuro</td>
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<td>1890</td>
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<td>590</td>
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</table>
### Ideal Vehicle Fleets* (energy-emissions)

<table>
<thead>
<tr>
<th></th>
<th>Low Density</th>
<th>High Density</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Depot Close to</strong></td>
<td>SADR/Udelv</td>
<td>SADR/Nuro</td>
</tr>
<tr>
<td>Service Area **</td>
<td></td>
<td></td>
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<tr>
<td><strong>Depot Far from</strong></td>
<td>Udelv/E-Van</td>
<td>Udelv</td>
</tr>
<tr>
<td>Service Area</td>
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* Range constraint results
** SADRs are best if no mothership is required
# Ideal Vehicle Fleets* (energy-emissions)

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<th>Low Density</th>
<th>High Density</th>
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<tbody>
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<td>Drone</td>
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<tr>
<td>Depot Far from Service Area</td>
<td>E-Van</td>
<td>Udelv/E-van</td>
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* Time constraint results
# Ideal Vehicle Fleets* (cost)

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<th>High Density</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Depot Close to Service Area</strong></td>
<td>Conv. Van</td>
<td>SADR**</td>
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<tr>
<td><strong>Depot Far from Service Area</strong></td>
<td>Conv. Van E-van</td>
<td>Conv. Van</td>
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* Range constraint results
** SADRs may be competitive if no mothership is required
# Ideal Vehicle Fleets* (cost)

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<tbody>
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<td><strong>Short delivery</strong></td>
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<tr>
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<tr>
<td><strong>Long delivery</strong></td>
<td>Mixed** Drone</td>
<td>Nuro/Udelv</td>
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<tr>
<td>time</td>
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</table>

* Time constrained results

** Mixed results depending on dominant constraint
Business to Consumer Last Yard Delivery Types

- ONTO THE PORCH
- INTO A MAILBOX
- INSIDE THE HOME OR CAR
- INTO A STORAGE Locker

Least Secure --------------------------------------------------------------- Most Secure
Amazon Key

Could be used to allow deliveries (by robot in the future) into home or car trunk
Cleveron’s Road Delivery Robot & Mailbox

Autonomous vehicle delivers to a smart mailbox or locker

https://youtu.be/jgBMMspyY0w?t=19
BTB

Delivery

Honeywell Robotic Unloader

https://www.youtube.com/watch?v=mTFBuSuYuZI
Technology not ready at scale to deploy

“The tech is not necessarily good enough right now that you can do it without having someone watching it”

MATTHEW JOHNSON-ROBERSON, REFRACTION ROBOTS, CEO AND COFOUNDER.

“Fundamentally, it’s that the technology is not ready at scale to deploy. We’re trying hard, I promise.”

DAVE FERGUSON, NURO PRESIDENT AND COFOUNDER

Figure Sources: https://www.wired.com/story/delivery-robots-arent-ready-when-needed-most/
Changing Landscape

- Freight and deliveries perceived as an essential service
- Cities/states willing to experiment with space and road reallocations
- Long-term realignments, “new normal” with more e-commerce and different supply chains
Consolidation of trends

- Ecommerce growth
- Package and service delivery growth
- Automation: deliveries, warehouses, lockers…
- More than one delivery vehicle type
COVID-19 longer-term impacts

- Remote working and brick&mortar shopping
- Labor and health issues
- More investment in contactless technologies
- Cities reallocating road and curb space
  - robotaxis
  - delivery vehicles
Publications


• Chauhan, D., Unnikrishnan, A., Figliozzi M., 2019, Maximum Coverage Facility Location problem with Drones, Transportation Research part C, 2019

• Jennings, D., & Figliozzi, M., 2020, A Study of Road Autonomous Delivery Robots and Their Potential Impacts on Freight Efficiency and Travel. Forthcoming *Transportation Research Record*.


• Plus reports and papers under review
Acknowledgments

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